Report for 2001AK3501B: Compatibility analyses of various snow measurements/data in Alaska

- Conference Proceedings:
  - Yang, D., B. E. Goodison, P. Y.T. Louie, and T. Ohata, Bias correction of gauge-measured precipitation data in the northern regions: applications of WMO methods, (Abstract) Proceedings of WCRP Workshop on Determination of Solid Precipitation in Cold Climate Regions, Fairbanks, Ak, June 9-14, 2002.
- Articles in Refereed Scientific Journals:
  - Yang, D., D.L. Kane, L.D. Hinzman, B.E. Goodison, J.R. Metcalfe, P.Y.T. Louie, G.H. Leavesley, D.G. Emerson, C.L. Hanson, 2000: An evaluation of the Wyoming gauge system for snowfall measurement. Water Resources Research, 36(9), 2665-2678.
  - Yang, D., B.E. Goodison, J.R. Metcalfe, P.Y.T. Louie, E. Elomaa, C.L. Hanson, V.S. Golubev, Th. Gunther, J. Fullwood, R. Johnson, J. Milkovic, M. Lapin, 2001: Compatibility evaluation of national precipitation gauge measurements. Journal of Geophysical Research-Atmospheres, Vol 106, No. D2, 1481-1491.
- unclassified:
  - Benning, J.L., D. Yang, and D. L. Kane, Adjustment of daily precipitation data at Barrow Alaska for 1995-2000. (Abstract) Proceedings of WCRP Workshop on Determination of Solid Precipitation in Cold Climate Regions, Fairbanks, Ak, June 9-14, 2002.

Report Follows:

Problem and Research Objectives

Snow is one of the key components in cold region hydrology and climate systems. It is also the most important variable in global change analyses, as changes of snowfall amount, snowcover extent and mass will have a major impact on hydrology, climate and ecosystems of the Earth. Long-term snow (i.e. snowfall and snowcover) data have been collected at observational networks and in some research watersheds in Alaska. These data, quality-controlled and archived by various organizations, have been widely used in climatic and hydrologic applications. Proper utilization and interpretation of these data in Alaska is extremely important and largely depends on the user's knowledge of the observational methods and data processing and archiving procedures.

Studies have shown that the accuracy and compatibility of snow measurements in cold regions including Alaska are generally very poor mainly due to the following factors: 1) precipitation gauge undercatch of snowfall by up to 50-70% at high wind conditions (Black 1954; Benson, 1983; Goodison et al., 1998; Yang et al., 1998a,b, 1999; Yang 1999); 2) poor spatial representativeness of point snow data (Benson, 1983; Woo et al., 1983; Yang and Woo, 1999); 3) incompatibility of various snowfall and snowcover observation methods and instruments (Woo et al., 1983; Yang et al., 2001). In order to better understand the limitation of various types of snow data and make a better use of them for climate, water resources and hydrology applications, this project compiled and analyzed all available snow data collected in Alaska to focus our research on the following key aspects:

- Quantify the accuracy of the National Weather Service (NWS) gauge measured precipitation data.
- Evaluate the performance of the Wyoming gauge system in Alaska.
- Define the compatibility of various snow measuremnts/data.

Methodology

The following methods have been used in data analyses for this research project:

a) Bias correction of the NWS gauge snowfall measurements: Bias correction of the NWS gauge snowfall data was based on the methodology derived from the World Meteorological Organization (WMO) gauge intercomparison project (Goodison et al., 1998). A correction procedure, developed by Yang et al. (1998b), has been applied on a daily basis to selected NWS climate stations. Daily records of air temperature, wind speed, gauge measured precipitation were needed for this analysis. Long-term data in difference climate regimes in Alaska were used for this study and reliable daily snowfall data were generated. A comparison between the measured and bias-corrected daily snowfall data was also conducted in order to assess the impact of bias-correction on climate change/variation analysis.

b) Compatibility analysis of bias-corrected gauge data vs. Wyoming gauge observations: Recently Yang et al (2000), using the WMO gauge intercomparison data, has reported that the Wyoming gauge system performed as well as the WMO reference (a Russian double fence system) and it can measure snowfall accurately in windy and cold conditions. To evaluate the bias-correction procedures and results, a comparison of bias-corrected snowfall data (daily and seasonal totals) with the Wyoming gauge measurements has been carried out at selected locations in Alaska.

c) Compatibility of the NWS snow depth observation with Natural Resources Conservation Service (NRCS) snow survey and SnowTel data: Snow depth data can be used to estimate the SWE by assigning a snow density to the measured snowpack or new snowfall. Snow density exhibits wide temporal and spatial variations, mainly due to variations of upper air temperature, wind speed and direction near the surface, the elapsed time of measurement of snowfall after the beginning or end of

the storm, the siting of the measurement station and the observer bias. It is difficult to apply universal corrections to daily snow depth data. However, intercomparisons of these measurements will crosscheck the data quality, quantify the systematic differences (if they exist), and lead to an establishment of transfer functions between these data/measurements.

Principal Findings and Significance

We have focused our effort on assessment of Wyoming gauge performance for snowfall observations and bias-correction of gauge measured data at selected climate stations in Alaska.

Analysis of Wyoming gauge data show that, in comparison with the DFIR (a Russian snow fence system), the mean snow catch efficiency of the Wyoming gauge was about 80– 90%. We found a close linear relation between the measurements of the two gauge systems and this relation may serve as a transfer function to adjust the Wyoming gauge records to obtain an estimate of the true snowfall amount. We also found that catch efficiency of the Wyoming gauge did not change with wind speed and temperature, and that Wyoming gauge measurements were generally compatible to the snowpack water equivalent measured at selected locations in northern Alaska. These results are important to our ongoing efforts to better quantify the water and energy balances in the research basins located on the North Slope of Alaska (Kane et al., 1999; Hinzman et al., 1998; Zhang et al., 2000). They are also useful for regional hydrologic and climatic analyses.

We found that daily adjustment for observational biases increased the gauge-measured annual precipitation by 65–800 mm (about 10–140% of the gauge-measured yearly total) at selected climate stations in Alaska (Yang et al., 2002; Benning et al., 2002). The NWS 8-inch standard gauges with an Alter wind shield have a much lower adjustment for wind-induced undercatch than the unshielded gauges. Monthly adjustment factors (adjusted/measured precipitation) differ by station, and at an individual station by type of precipitation. We identified considerable intra-annual variation of the magnitude of the adjustments in Alaska owing to the fluctuation of wind speed, air temperature, and frequency of snowfall (Benning et al., 2002). We confirmed that the adjustments of gauge observational errors significantly impact climate monitoring and change analysis.

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